Thermal Conductivity of Titanium-Base Alloys and High-Alloy Steels at Low Temperatures

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For the sake of prediction of the thermophysical properties of new construction materials without expensive experiments, we have experimentally investigated the thermal conductivity of a number of important single-phase titanium-base alloys and high-alloy steels over a temperature range of 4.2-300 K. The thermal conductivity of all the investigated materials increases monotonically with increasing temperature, reaching a saturation value at room temperature. Such behavior is characteristic of metals with highly deformed crystal lattice. An analysis of the data shows that the influence of doping on thermal conductivity is connected mainly with the total concentration of doped elements rather than with their peculiar features. At any temperature below 300 K, the thermal conductivity of all the investigated materials decreases monotonically with an increase in the total concentration of doped elements (Σ) and, in fact, does not depends on Σ for $\Sigma > 10$ at.% for titanium-base alloys and $\Sigma > 25$ at.% for high-alloy steels. The cause of such a saturation is that, because a large concentration of defects, the mean free path of heat carriers reaches a minimum value close to the interatomic distance. The thermal diffusivity and thermomechanical parameter (the ratio between the proof stress and thermal conductivity) have been also found for all the materials investigated. The thermomechanical parameter decreases rapidly with increasing temperature. It is larger for the titanium-base alloys than for the high-alloy steels; among the steels, it is maximum at low temperatures for austenitic and martensitic ones.

The obtained experimental data on the thermal conductivity of 10 titanium-base alloys and 32 high-alloy steels will be used as reference data for the National Standard Service of Ukraine.